A new Albian Teleost, *Euroka dunravenensis* gen. et sp. nov. and a new family, Eurokidae, from the Eromanga Basin of Queensland

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ABSTRACT

The Lower Cretaceous (latest middle to late Albian) marine sediments of the Eromanga Basin portion of the Great Artesian Basin in Queensland, Australia continue to yield additional species of teleosts that expand knowledge of the early radiation of the Elopomorpha. The new genus and species, *Euroka dunravenensis*, is described from the Toolebuc Formation and a new family, the Eurokidae, has been created to accommodate this very specialised, large predator that has highly adapted morphological features especially those associated with the roof of its mouth. The parasphenoid and vomer are very broad to compensate for its solid, bar-like anterior hyopalatine elements. Vomerine and palatine teeth are extremely large. The lower jaw is also very strongly developed, with its lower margin recumbent and with a solid, broad, internal shelf present to further strengthen and accommodate the extent of the ventral penetration of the large teeth from the roof of the mouth. It appears that circumorbital bones may have been much reduced in number but heavy while the preoperculum was sigmoidally shaped and also robust. The neurocranium was very broadened and flattened. The taxon shows that early radiation of the elopomorphs was more complex than previously recognised. ❐ *Teleost, Albian, Eromanga Basin, Toolebuc Formation, Euroka dunravenensis, Elopomorpha, ?Albuloidei, Eurokidae.*

Among collections of teleost fishes made by the author and staff of the Queensland Museum from the Toolebuc and Allaru Formations of Lower Cretaceous (latest middle to late Albian) age in the northern part of the Eromanga Basin (a part of the Great Artesian Basin) are a number of early representatives of the Elopomorpha. These are being progressively prepared and are adding significant detail to the morphology of already identified species or are proving to represent taxa that are new to the described fauna.

Entry of oceanic waters into the epeiric sea that covered much of inland Queensland during the deposition of the Albian sediments was over the basement structure known as the Euroka Arch. This partially separated the Eromanga Basin from the more northerly Carpentaria Basin, both parts of the expansive Great Artesian Basin. The Toolebuc Formation is a thin body of sediment (much thinner than the Allaru Formation) that is especially rich in remains of marine fossils and, being widespread but poorly exposed, shows evidence for some variation in its vertebrate faunal composition from place to place. Most discoveries occur within residual calcilutite concretions located at the surface, as at localities above the Euroka Arch. However, there is increasing interest in rare exposures of the sedimentary rock itself and in quarries being worked by local authorities for road work. Discoveries of more complete specimens of several species of fish have been reported from the Kronosaurus Korner Museum, Richmond, working such quarries in its immediate vicinity in central northern Queensland.

The crushed and somewhat distorted neurocranium that is the holotype of *Euroka dunravenensis*, was prepared by acetic acid treatment from an isolated concretion, from close to the area underlain by the Euroka Arch and the referred posterior of a skull is from near Richmond. Unfortunately, no post-cranial remains have been found, other than those immediately behind the neurocranium of the holotype and it is to be hoped that future field work by the Queensland Museum or by local museums in the area will provide additional detail for this enigmatic fish.

The author wishes to acknowledge the preparation work undertaken on the holotype by his Assistant, Ms Tempe Lees and the critical review and input into the manuscript by Dr Alex Cook of the Queensland Museum.

ABBREVIATIONS USED IN TEXT FIGURES

ace . . . . anterior ceratohyal
ang . . . . angular
apal . . . . autopalatine
asp . . . . autosphenotic
bo . . . . basioccipital
brr . . . . branchiostegal ray
de . . . . dermethmoid
den . . . . dentary
df. . . . . dilitator fossa
dpal. . . . . dermopalatine
e.com . . . . . . ethmoid commissure
ecp . . . . ectopterygoid
enp . . . . endopterygoid
epo . . . . epiotic
exo . . . . exoccipital
exo.ic . . . . . . exoccipital-intercalar ridge
fahm . . . . hyomandibular facet
fm . . . . foramen magnum
fr . . . . frontal
hm. . . . . hyomandibular
ic . . . . intercalar
io . . . . infraorbital
iop. . . . . interoperculum
l.e . . . . lateral ethmoid
mes . . . . mesethmoid
mpt . . . . metapterygoid
m.s.c.. . . . . . . mandibular sensory canal
mx. . . . . maxilla
op . . . . operculum
ors . . . . orbitosphenoid
ot.s.c.. . . . . . . otic sensory canal
pa . . . . parietal
par. . . . . parasphenoid
part.p . . . . . . postarticular process
pop . . . . preoperculum
pro . . . . prootic
psp . . . . pterosphenoid
ptf . . . . post-temporal fossa
pto. . . . . pterotic
qu . . . . quadrate
rart . . . . retroarticular
smx . . . . supramaxilla
soc. . . . . supraoccipital
soc sp . . . . . . supraoccipital spine
sop . . . . suboperculum
so. s.c. . . . . . . supraorbital sensory canal
suf . . . . subtemporal fossa
vhh . . . . ventral hypohyal
vo . . . . vomer
VII hm . . . . . . foramen for hyomandibular trunk of facial
VII ot . . . . . . foramen for otic branch of facial
IX. . . . . glossopharangeal foramen
X . . . . foramen for vagus

SYSTEMATIC PALAEONTOLOGY

Order Elopiformes

Suborder ?Albuloidei

Family **EUROKIDAE** fam. nov.

Family Diagnosis. Elopiform fishes in which the skull is posteriorly very broad and very shallow. Subtemporal fossa is very weakly developed. Snout is moderately elongated and the mouth is terminal. Ethmoid commissure is incomplete. Supraorbital sensory canal does not extend onto parietal and its ridge is anteriorly shortened. Parietals are relatively small, diamond-shaped and separated posteriorly by supra-occipital. Occipital condyle is formed by basioccipital. Otic bullae insignificant. Ossified interorbital septum to the parasphenoid is elongated and very thickened posteriorly. Lateral ethmoid is relatively small but complex, with its posteromedial body firmly sutured ventrally to lateral margin of parasphenoid and posterolateral base abutting endopterygoid. Parasphenoid is edentulous and very broad. Vomer is solidly attached to the mesethmoid and locked in laterally by vertical, reciprocal, interlocking processes; it bears very large, near-conical teeth. Ectopterygoid, endopterygoid, dermopalatine and autopalatine are all very robust, united into solid bar; both palatine elements have very large, slightly incurved, conical teeth. Maxilla posteriorly carries relatively small, conical teeth, ankylosed to internal shelf and supported laterally by lateral flange. Two supramaxillae are present. Mandible is robust, strengthened by large internal shelf. Dentary deep anteriorly with ventral margin recumbent. Low coronoid process well anterior to articulatory facet. Mandibular teeth are larger than maxillary but are similarly attached; two, much larger, anterior, tusk-like teeth present. A small, robust, retroarticular is present. Gular is well developed and at least 20 branchiostegal rays exist on each side, with posterior rays very spathiform and elongated. Circumorbital series much reduced. The preoperculum is thickened anteriorly and sigmoidal in shape. Interoperculum and suboperculum are elongated and deep.

Euroka gen. nov.

Generic Diagnosis. As for the species until further taxa are defined.

Type Species. *Euroka dunravenensis* sp. nov.

Etymology. Named for the subsurface Euroka Arch above and to the south of which the holotype of the type species was collected.

Euroka dunravenensis sp. nov.
(Figs 1-8)

Holotype. QMF13766, almost complete skull, crushed dorsoventrally and posterolaterally with a degree of rolling giving it an exaggerated fusiform appearance, lacking the premaxilla, most of the maxilla and possibly some cheek bones and part of the posterior of the neurocranium, from bank of unnamed tributary of Stewart Creek, "Dunraven" Station, N of Hughenden, NCQ.

Referred Specimen. QMF12759, posterior of incomplete neurocranium, showing some dorsoventral crushing with slight anterior rotation of ventral elements and with some dorsal shedding of surface bone, from "Redcliffe" Station, ENE of Richmond, NCQ.

Formation. Toolebuc Formation of latest middle to late Albian (Lower Cretaceous) age.

Etymology. The species was named for "Dunraven" Station, N of Hughenden, NCQ, the property from which many fossil fish species have been collected.

Diagnosis. Large elopiform teleost with skull in holotype exceeding 30 cm in length and over 13 cm broad posteriorly. Neurocranial roof longitudinally flat, posteriorly broad and shallow (5.7 cm deep) and only slightly arched across occipital region, lacking strong ornamentation. Dilitator fossa shallow but very broadly roofed. Anterior of hyomandibular facet deeply pocketed and shared by both autosphenotic and prootic. Dermethmoid much broadened posteriorly

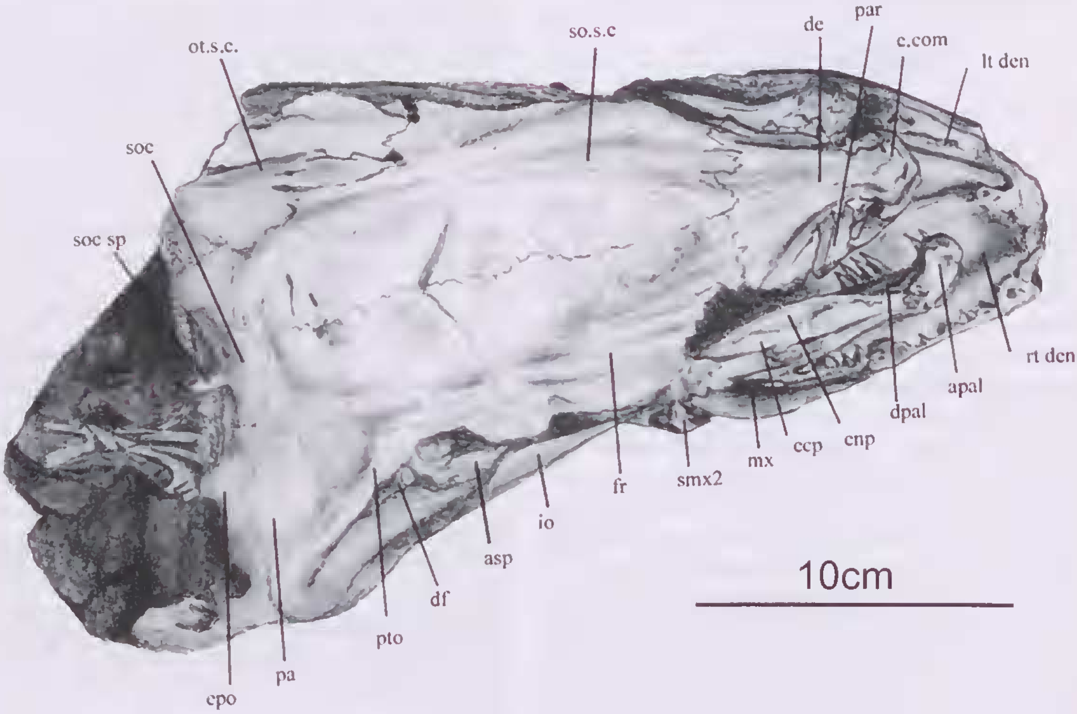

FIG. 1. *Euroka dunravenensis* gen. et sp. nov., Holotype, QMF13766, neurocranium in dorsal view.

and firmly sutured to the frontals; overlying medial body of mesethmoid and hooked over its anterodorsal surface. Mesethmoid complex, supporting robust vomer. Two large vomerine teeth present, slightly recurved and slightly longitudinally oval in section, with anterior exceeding 12 mm in length and posterior about 8 mm in length. Parasphenoid anteriorly very broad. Epiotic process weak. Supraoccipital spine relatively well developed. Angular, horizontal flexure present across exoccipitals, reducing sub-epiotic fossa. Subtemporal fossa almost non-existant, with bones on side of brain case almost horizontal. Post-temporal fossa angled anteromedially, with reduced external opening. Intercalar contributes minimally to exoccipital-intercalar ridge that terminates bluntly at exoccipital/prootic suture. Autosphenotic with weak spine and with ventral base broadly rounded; posterior face near vertical. Pterosphenoid lobate, relatively large. Orbitosphenoid with very thick interorbital septum. Infraorbitals reduced in number, with posteroventral infraorbital strong, elongated, lozenge-shaped. Quadrate / mandibular articulation below back of orbit. Two large autopalatine teeth present, with anterior 8 mm long and posterior 14 mm long, separated from from four, large, dermopalatine teeth by diastema. Anterior dermopalatine tooth 15 mm long and 7 mm in diameter. Palatine teeth round in section and slightly incurved at tips. Anterior ceratohyal elongate. Lower jaws very large, deep, basally recumbent, strengthened by broad internal shelf. Coronoid process low, well separated from jaw articulation. Teeth pointed, circular in section with tips slightly incurved and slightly larger than those on maxilla with latter up to 2.8 mm long. Mandibular teeth up to 9 mm long above rim of dentary (excluding two, larger, anterior, tusk-like teeth). Gular elongate, narrow anteriorly, broader and scalloped posteriorly between numerous longitudinal ridges.

Description. A large teleost probably exceeding a metre in total length. Neurocranium of holotype crushed dorsoventrally and posterolaterally. Sample lacks premaxilla, most of maxilla and, if ever present, most of the infraorbitals. The postcranial skeleton is largely unknown. The posterior neurocranial surface is shallowly concave transversely in dorsal view. The surface slopes anteriorly above and below a broadly angled, transverse flexure at the level of the foramen magnum at the junction of the exoccipitals with the epiotics and supraoccipital. The neurocranium is shallow in the occipital region but this still represents the deepest part of the skull. Occipital breadth in the holotype is ca. 13 cm but depth is not able to be measured. Occipital breadth in QMF12759 is 12.5 cm, while its occipital depth is 5.87 cm. Postorbital length in this specimen is 9.96 cm.

Neurocranium. The frontals and parietals make up the bulk of the longitudinally flat neurocranial roof. Transversely, the roof is only slightly convex in the occipital region. The frontals have strong, broad junctions with the dermethmoid. Each frontal carries a strong, curved, longitudinal ridge for the supraorbital sensory canal, positioned about one-half the distance from the medial frontal suture to the lateral border above the orbit. Posteriorly, the neurocranial roof is slightly depressed medially but this is probably accentuated by crushing. Above the orbit, the frontal is flattened across its sutured junction with its counterpart. The dorsal surface is only very slightly ornamented with variable ridges that originate from centres above the posterior of the orbit. Those more directly linking the centres of ossification are somewhat stronger. The anterolateral surface bears much broader, low, radiating folds from the same centres. The suture that unites each frontal and parietal is difficult to locate in the holotype but is more readily identifiable in QMF12759.

The dermethmoid in dorsal view is a large, spool-shaped, relatively simple element, much broader posteriorly than anteriorly, with a waisted section above the olfactory capsule. It is thin and anteriorly is bluntly pointed in dorsal view. Its posterior surface is slightly depressed medially, within low, anteriorly converging ridges that unite above the waisted area to form a slightly raised anteriorly surface. More sharply defined ridges are present immediately behind and above the olfactory capsule near the lateral margins of the bone, separated by shallow grooves from the inner ridges. These disappear posteriorly. The dermethmoid is bluntly pointed and overlies the body of the mesethmoid, wrapping around its anterodorsal border and contributing ventrolaterally to the upper border of a single premaxillary facet. This "hook" meets the vomer and is separated from the medial dorsal convexity of the dermethmoid by a shallow, well-defined groove that opens posteriorly on each side, separating the two longitudinal ridges on the bone. This groove is partially capped by remains of thin bone and appears to represent an incomplete, anteriorly curved, ethmoid commissure.

The mesethmoid is a complex element that appears to be fully ossified. Anteriorly, it continues ventrally from its junction with the dermethmoid, providing a shallow articulation dorsolaterally, the premaxillary facet. Ventrally, it meets and completes the anterior support for the vomer. Anterolaterally, it extends dorsally as an interlocking process, then extends posterodorsally, to underlie the back of the dermethmoid, meeting the upper surface of the vomer and anterior of the parasphenoid,. It contributes to the olfactory capsule posterventral to an interlocking, vertical arm of the vomer.

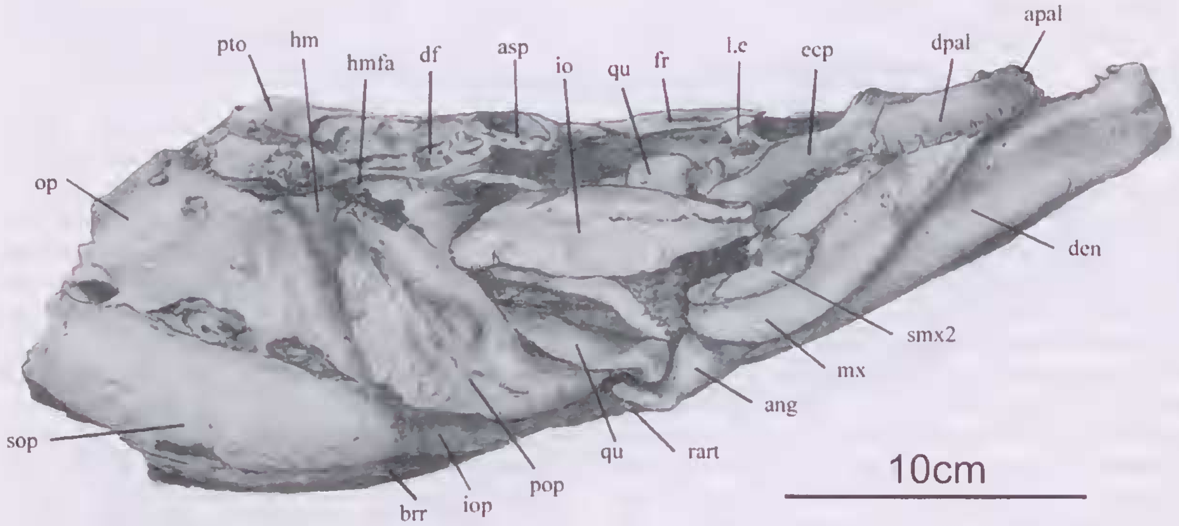

FIG. 2. *Euroka dunravenensis* gen. et sp. nov., Holotype, QMF13766, neurocranium in lateral view.

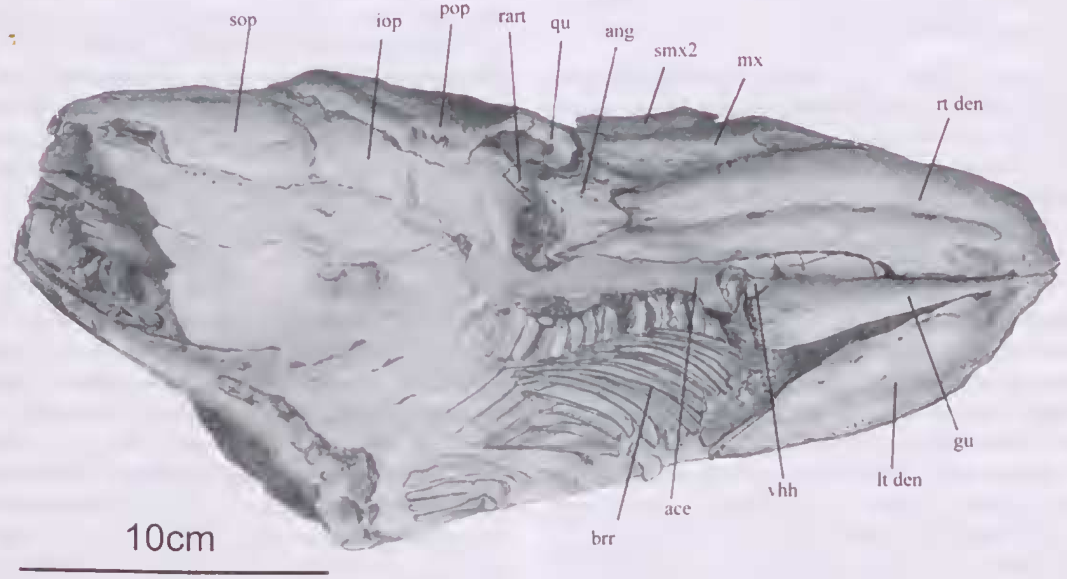

FIG. 3. *Euroka dunravenensis* gen. et sp. nov., Holotype, QMF13766, neurocranium in ventral view.

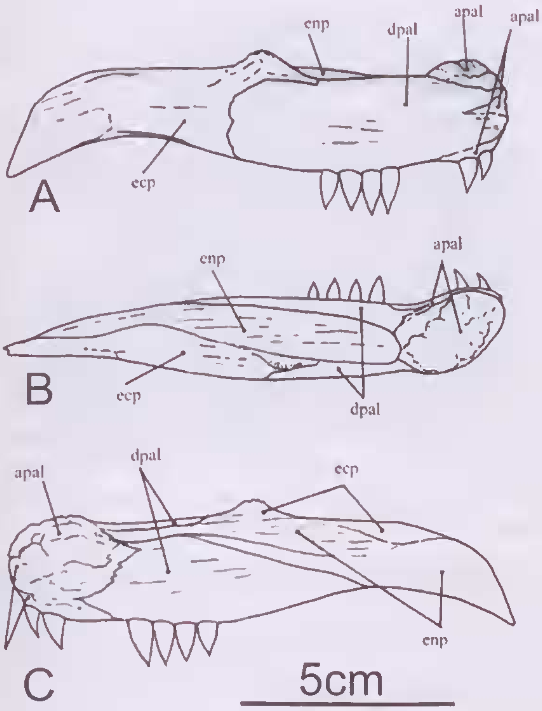

FIG. 4. *Euroka dunravenensis* gen. et sp. nov., Holotype, QMF13766, anterior hyopalatine bones. A, lateral view; B, dorsal view; C, medial view.

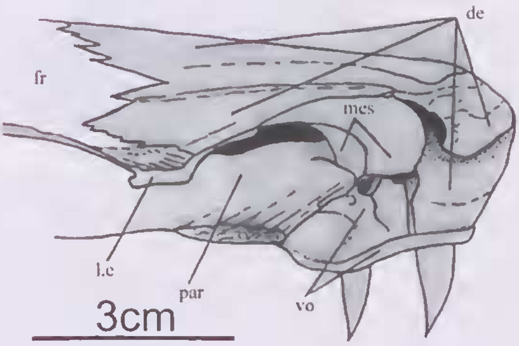

FIG. 5. *Euroka dunravenensis* gen. et sp. nov., Holotype, QMF13766, sketch of anterior of neurocranium, lateral view (premaxilla not preserved).

The parietal is a small bone, broader than it is long but its sutures with surrounding bones are difficult to define. It lies behind the posterolateral back of a depressed posterior of the neurocranial surface. A dorsal wedge of the supraoccipital separates the parietals. A continuation of the ridge on the frontal, above the supraorbital sensory canal, extends towards the parietal but does not appear to reach it. The parietal dorsal surface is relatively unornamented.

The pterotic makes up the bulk of the posterolateral part of the neurocranial roof and contributes the lateral and dorsolateral margins of the small, post-temporal fossa. Medially, the junction of the pterotic with the parietal is short. The cranium is widest at the posteroventral corner of the pterotics. The dilatator fossa is shallow and very broad and is almost fully roofed by the pterotic. The anterior of the dilatator fossa is provided by the autosphenotic. A large fenestra is present at the anterior of the dilatator fossa, penetrating medially. The pterotic also contributes the bulk of the roof of the hyomandibular facet that is separated from the base of the dilatator fossa by a strong, near-horizontal ridge. The otic sensory canal is not well defined but appears to have been covered. Dorsomedially the junction of the pterotic and parietal is short. The post-temporal fossa is well developed and angled anteromedially. Within the post-temporal fossa, the pterotic makes a broad, transverse contact with the intercalar but only just extends ventrally to form the extreme posteroventral margin of the fossa. Its longitudinal contact with the epiotic is in the base of the fossa. Posteroventrally, the pterotic is expanded and has long, sutured contacts with the intercalar and prootic.

The autosphenotic is subtriangular with a low, anterolateral shelf. Its body is tapered laterally and expanded at the tip into a reduced autosphenotic spine that does not extend beyond the margin of the neurocranial roof. The base of the spine is broadly convex anteroposteriorly and is ornamented with low ridges. Anteriorly, the face is penetrated by a foramen for the otic component of nerve VII. The posteromedial face is near vertical and forms the anterior of the dilatator fossa.

The supraoccipital is a relatively small element that is slightly transversely concave, positioned medially in the dished posterior neurocranial surface. It extends about one-half the distance from the midline to the inner margin of the post-temporal fossa. It is pocketed on each side of a moderate, posteriorly directed spine, with the pocket separated from the exoccipital by a dorsolateral ridge. The pocket extends across the back of the neurocranium onto the epiotic as a weak subepiotic fossa. The supraoccipital extends relatively broadly onto the dorsal surface of the neurocranium to separate the posterior of the parietals. It is strongly united with the epiotic laterally.

The epiotic extends laterally from its junction with the supraoccipital to near the middle of the dorsal rim of the post-temporal fossa beyond a muted epiotic process. It has greater expression on the dorsal surface than the supraoccipital. Its slightly pocketed posterior surface contributes to the poorly developed subepiotic fossa. It provides much of the dorsomedial margin and wall of the post-temporal fossa.

The exoccipital is relatively large but appears to be excluded from below the ventromedial margin of the post-temporal fossa by the epiotic and intercalar. It lies below the transverse flexure of the posterior neurocranial surface and provides the margins of the foramen magnum. It is penetrated by the foramen for the occipital nerve. It does not appear to form the floor of the foramen magnum. It curves anteroventrallyclose to the basioccipital and extends anteriorly to just behind the back of the parasphenoid. Laterally, it bears a low but major contribution to an exoccipital-intercalar ridge to the prootic. The foramen for the vagus nerve is small, beside the posterodorsal margin of the basioccipital and its junction with the exoccipital.

The intercalar is a relatively large element that caps the posteroventral, inner corner of the post-temporal fossa and extends across and dorsally to and slightly above the ventromedial part of the margin. It provides most of the posteroventral neurocranial surface, meeting the exoccipital along an elongated posterolaterally angled ridge, broadening anteromedially and contributing minimally to a low, exoccipital-intercalar ridge that terminates bluntly above the prootic-exoccipital suture. A foramen near this appears to be the opening for the pars jugularis. Laterally, the subtemporal fossa is almost non-existant.

The basioccipital forms the occipital condyle. Dorsally, it bears two deep pits for attachment of a neural arch and ventrally is deeply grooved towards the occipital condyle, at the back of the myodome, posterior to the prongs of the parasphenoid.

The prootic is large and complex. It is the largest element of the lateral neurocranial wall. Posterolaterally, it lies at only a slight angle from the horizontal and links laterally with the autosphenotic and pterotic, posteriorly with the intercalar, the exoccipital and the basioccipital, ventromedially with the exoccipital, the basioccipital and parasphenoid and anteriorly with the autosphenotic and pterosphenoid. Anterolaterally, it contributes the facet for the anterior of the hyomandibular. The shape of the hyomandibular facet indicates that the hyomandibular possessed a very broad head. A large foramen close to the ascending wing of the parasphenoid is for the hyomandibular trunk of the facial nerve. The foramen for the orbital artery is present anteromedially and close to this. The anterior face of the prootic forms much of the posterior margin of the orbit.

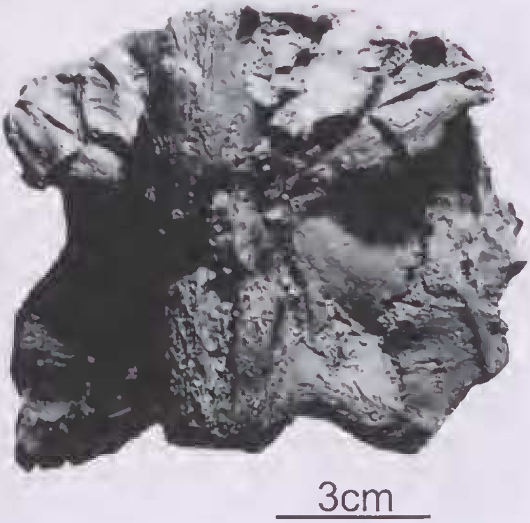

FIG. 6. *Euroka dunravenensis* gen. et sp. nov., QMF12759, ventral view of posterior of partial neurocranium.

Crushing has masked the foramina for the oculomotor nerve and the anterior opening of the pars jugularis.

The pterosphenoid is moderately large, near horizontal, being only slightly inclined anteriorly. Its anterolateral margin is rounded. Two small foramina are present towards the medial margin. The surface of the bone is plicated radially towards the lateral margin.

The basisphenoid is represented only by part of the upper arm of its broadly Y-shaped shape. This is angled posteriorly and separated from much of the medial margin of the petrosphenoid by an elongate, slit-like foramen for the optic nerve, but this has probably been narrowed by crushing.

The orbitosphenoid is represented only by its posterior margin. The dorsal attachment to the frontal is very solid and the bone has only minor penetration on each side, just above the level of the front of the pterosphenoid,

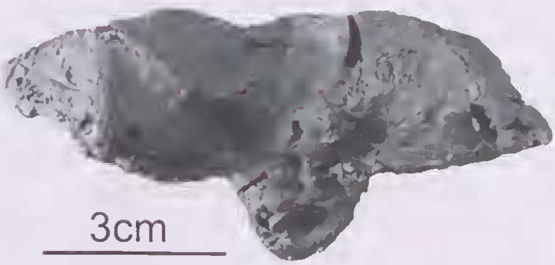

FIG. 7. *Euroka dunravenensis* gen. et sp. nov., QMF12759, posterior view back of partial neurocranium.

possibly for passage of the olfactory tract. The orbitosphenoid is attached to the upper surface of the parasphenoid by an ossified interorbital septum that is massively solid, posteriorly almost as wide as the parasphenoid itself.

The parasphenoid is only partially known. It is very robust, short posteriorly, with the back produced into forked, short, thickened prongs. The ascending wings are almost non-existant and the foramina for the internal carotid arteries are present near their bases. Anterior to the ascending wings, the bone is transversely slightly convex with an edentulous but rugose surface. A medial foramen is present below the back of the orbitosphenoid, possibly for the efferent pseudobranchial artery. The lateral margin of the parasphenoid is greatly expanded, especially towards the front, greatly increasing its contribution to the roof of the mouth, compensating for the blockiness of the anterior hyopalatine elements. The extreme anterolateral margin is slightly deepened and appears to have contributed to the support for the anterior process of the dermopalatine.

The lateral ethmoid is a relatively complex element with its laterally visible body well posterior to the mesethmoid, firmly uniting the base of the frontal to the thin, upturned, lateral margin of the parasphenoid. This mesial, posteroventral projection together with the back of the body of the bone constitutes the posterior of the minor, anterior orbital margin. Anterodorsally, the body of the bone laterally provides the back of the olfactory capsule, while at the posteroventral external corner, a prominent but short process provides the articulatory surface for the cartilaginous connection with the dorsal process of the ectopterygoid. Separation of these two articulatory surfaces in the holotype shows that the backwards displacement of the dorsal neurocranial elements relative to the lower neurocranial elements, was of the order of 3.5 cm. Dorsally, the bone extends and underlies the concave, lateral margin of the frontal, progressively thinning to the anterolateral edge of the olfactory capsule. Anteromedially, it thins towards the anterior of the ossified interorbital septum and probably does not meet its counterpart from the other side. It projects anteriorly to the posterior of the mesethmoid, providing additional support for the upper, medial part of the parasphenoid.

The vomer is a very solid, unpaired bone broadly supported anterodorsally by the base of the mesethmoid below the hooked anterior of the dermethmoid. Posterodorsally, it thickens to meet the body of the mesethmoid and laterally meets the expanded anterior margin of the parasphenoid. It is produced into a vertical, interlocking process into the side of the mesethmoid, midway along the lateral margin. Ventrally, the vomer is broadly concave along its midline and anterolaterally bears a very large, pointed, 12 mm long tooth on each side in the holotype. The tooth is longitudinally ovate in section and its tip is recurved. A somewhat smaller but otherwise similar tooth is present on each side at the edge of the vomer and is separated from that at the front by a long diastema. This tooth is some 8 mm long and lies inside the front of the parasphenoid. Again, the left side counterpart of this tooth is not visible in the holotype. Posteroventrally, the vomer is pocketed to contribute, with the base of the front of the parasphenoid, to the facet for the anterior process of the dermopalatine.

Hyopalatine bones. Hyopalatine bones are, in part, incompletely preserved or are masked by overlying elements. The hyomandibular is covered by other elements but the hyomandibular facet is elongate and subparallel to the neurocranial roof, suggesting that the head of the hyopalatine was broad and the bone was somewhat less inclined anteriorly than the distortion noted in the holotype suggests.

The quadrate is expanded and widely fan-shaped. The articulation for the lower jaw is transversely broad and inclined anteriorly but this is again possibly somewhat accentuated by posterior movement of the neurocranium relative to the lower jaw. A deep groove that probably accommodated the symplectic, separates an expanded posterior margin. The extent of its contact with the metapterygoid is masked and the symplectic is similarly obscured. Contact with the descending arm of the ectopterygoid was limited.

The ectopterygoid is a deep, robust bone, with its lateral surface slightly convex dorsoventrally and with its dorsal surface expanding medially and separated by an abrupt drop to the endopterygoid. Towards the back, it carries a sharp ridge that crosses towards the posterior margin. It is firmly united anteriorly with the dermopalatine along a deeply sinuous junction. The posterior of the ectopterygoid is broadly attenuated and slightly flexed ventrally and this bears a shallow, facet to accommodate the anterodorsal edge of the quadrate. Anterolaterally, the ectopterygoid extends dorsally above the level of the dermopalatine as a strong articulatory lateral process to contact the lateral ethmoid.

The endopterygoid is somewhat shallower but longer bone than the ectopterygoid. It is strongly attached posterolaterally to the ectopterygoid and extends dorsally across as the slightly

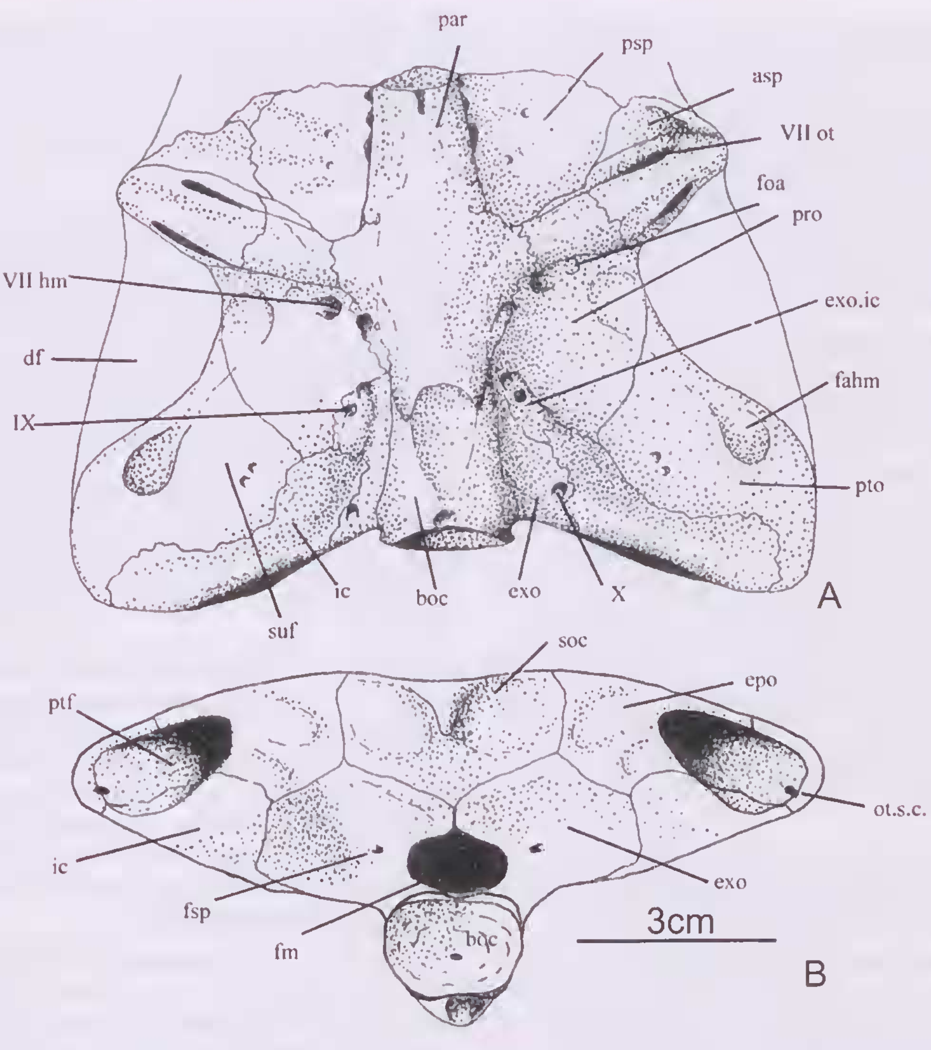

FIG. 8. *Euroka dunravenensis* gen. et sp. nov., reconstruction of QMF12759, posterior of partial neurocranium. A, ventral view; B, posterior view.

concave surface of the united elements to meet the autopalatine, behind the anterior process. This surface bears fine, irregular, longitudinal ridges. Its medial suture with the dermopalatine is angled posteroventrally. The bone meets the lateral arm of the dermopalatine along a dorsal rim that is deeper and sharper than that at the dorsolateral contact with the ectopterygoid, with the latter extending only to slightly below the level of the strong process on the ectopterygoid.

The autopalatine is a short but robust nugget of bone, forming the knob-like anterior process as well as the anteromedial and part of the anterior of the hyopalatine series. It is firmly united posteriorly with the anterior surfaces of the dermopalatine. The dorsal surface is sloped anterodorsally and somewhat dorsomedially as the anterior process and, while generally flattened transversely and gently curved longitudinally, it is marked by several small knobs and ridges at the outer edges.The ventral surface carries two large, pointed teeth that are near circular in section and that have their tips incurved and directed slightly backwards. The anterior tooth is smaller being 8 mm long, while the second tooth is 14 mm long.

The dermopalatine is a very large, deep, element that forms the majority of the anteromedial and anterolateral parts of the solid hyopalatine series. Laterally, it is deep and robust and extends posteriorly to its deeply digitated suture with the ectopterygoid. The lateral surface is gently dorsoventrally convex. Internally, the dermopalatine is attenuated from above its dentition along its junction with the endopterygoid. It bears at least four, extremely large, pointed and slightly incurved teeth along the anteroventral border, with the anterior one ca. 15mm long and 7 mm in diameter. These are closely placed in a single row but are separated by a short diastema from those on the autopalatine.

The metapterygoid is represented only by fragments of thin bone, largely masked by external bones of the skull.

Dermal upper jaw. The maxilla is known only from a posterior portion of the bone on the right side of the skull. It is relatively shallow and extends posteriorly to just in front of the articulation with the lower jaw. It has a narrow and thin upper flange that thickens markedly towards the tooth row, giving it a strongly convex profile across its ventral moiety. It is gently convex along its length but it appears to have been sinuous anteriorly. It is ornamented externally behind the tooth row with numerous, fine ridges and grooves and, more dorsally by numerous, very small tubercles. The back of the maxilla is convex, without a posterior notch. Internally, several small conical processes are directed medially. Maxillary dentition comprises a limited number of small, conical teeth in a single series, ankylosed to an internal shelf and supported laterally by a low flange. Teeth are up to 2.8 mm long.

A small but robust part of supramaxilla 2 is firmly attached to the posterodorsal corner of the maxilla, over the thin upper flange. The anterior of the bone is notched and then expands markedly in its anterodorsal moiety to a stout, rounded process that is directed posteromedially. This may have provided support for the back of the robust infraorbital positioned above. The head of the process bears a convex articulating surface. The anterior continuation of the flange of the maxilla and the notch in the anterior face of supramaxilla 2 supports the presence of a supramaxilla 1, lost during fossilisation in the holotype.

Mandible. The mandible is incomplete anteriorly but is only slightly reduced by this. It is elongate, very robust, deep and strongly developed with a shallow symphysis. The two sides of the lower jaw are only moderately divergent and the anterior is shallowly U-shaped across the symphysis. The base of the lower jaw is strongly inflected, especially in the area of a lower, well-developed flange.

The dentary comprises most of the mandible. The ventral margin is near horizontal in lateral view but the bone itself is anteriorly more expansive dorsoventrally than it is posteriorly. The oral margin curves gently ventrally, anterior to the low coronoid process, except where it descends more abruptly at the extreme anterior to the symphysis. It is tooth bearing over much of its length. The dentary teeth are moderately large, generally being much larger than those on the maxilla. Each is round in section, with slightly recurved tips. Remains of 12 teeth are present, each ankylosed at its base to an extensive, internal shelf of bone, slightly below a thin lateral flange of bone forming the oral border that supports the lateral bases of the teeth. A shallow groove exists internal to the bases of the teeth. Teeth in the back of the row increase gradually in size to the fourth last tooth, with smaller teeth then present to remains of the base of the third tooth from the front of the row preserved in the holotype. This tooth base and that in front of it suggest they were much larger than all other teeth in the dentary row and were tusk-like. In an undistorted specimen, they would have lain outside the large vomerine teeth. A very well developed, internal shelf is present medial to the bases of the teeth, curving abruptly to the lateral extent of the interior of the inflected basal flange of the bone. No coronoid teeth are present although the size of the inner shelf is similar to that where such teeth are present. The external surface of the dentary is externally marked by a deep, longitudinal groove that separates the upper, swollen body of the bone from the broad, thin flange running from the symphysis to below the articulation. The groove is penetrated by a number of prominent foramina for the mandibular sensory canal. The upper one-half of the main body of the dentary towards the rear of the tooth row is ornamented by very fine tubercles, becoming slightly larger posteriorly.

The angular is relatively small and deeply sutured to the dentary. It forms the outer part of the articulatory cup and posteriorly is elevated into a high, strong, prominent post-articular process. The interior of the posterior of the mandible is not exposed.

The retroarticular is present, represented by a small but robust knob of bone attached to the posterior end of the mandible, with contact with both the angular and the back of the basal, inflected flange of the dentary.

Circumorbital series. Only one infraorbital has been well preserved, positioned above the posterior of the supraorbital in the holotype. This is a robust, elongated, lozenge-shaped bone, with the anterior more attenuated. It is generally thicker than are most infraorbitals, ornamented externally with low, broad ridges and has the posterior moiety of its dorsal margin bevelled. Below the anterodorsal margin, the bone is thickened above an irregular, longitudinal groove and ventral flange. This is penetrated by small, posteroventrally directed canals and pores associated with the enclosed, infraorbital sensory canal. A prominent groove is present around the posteroventral edge before being directed posterodorsally across the lateral surface towards the anterior of the preoperculum.

Fragmentary remains of what appears to be other Infraorbitals and part of a possible dermosphenotic are present, displaced to above and behind this well preserved element.

Hyoid arch, gill arches and gular plate. The hyoid arch is only partly exposed. Only the posterior of a robust hypohyal element is exposed in the holotype. Articulating with this is much of the body of an extremely large ceratohyal. This is thickened anteriorly and becomes thinner and broader posteriorly, extending beyond the end of the mandible.

Branchiostegal rays are well exposed in the holotype, especially on the right side which has at least 20 rays present. The anterior 14 are relatively thin and distally pointed, with a thickened lateral surface, separated from a thinner surface by a longitudinal groove. The grooves diminish and almost disappear in the more posterior of these anterior rays; and these rays have a thickened posterior margin and a thin flange that broadens proximally. Within the series of branchiostegal rays, the more posterior 6 or possibly more become increasingly spathiform. Because of their thinning, they have been subjected to fretting of their edges, making it difficult to separate them. The last ray is extremely spathiform and has ornamentation of fine tubercles along its dorsal margin.

Gill arches are only represented by fragments that are not well enough preserved to warrant description.

The gular is present, lying between and dorsal to the lower flanges of the dentaries in the holotype. It is elongate, narrowly U-shaped ventrally towards the front, broadening and clearly scalloped posteriorly, with short, subparallel, longitudinal ridges extending into points and, with the intervening grooves, producing the scalloped margin.

Opercular series. The preoperculum is a solid, robust, sigmoidally-shaped bone with its sensory canal opening posteroventrally. It has a thickened anterior moiety that is slightly poteriorly curved at its dorsal tip and that is strongly curved anteriorly into a deep, ventral point that lies along the posterior of the quadrate. Its dorsal end lies close to the back of the pterotic but this may have resulted from displacement. The thickened anterior moiety is externally roughened and further ornamented by three broad grooves running subparallel to the posterior border. The posterior moiety of the bone is thinner, curves gently over the operculum and is more strongly curved posteroventrally to disappear near the anterior base of the element. Some shedding may have occurred at the posteroventral margin.

The operculum is known only from a small, poorly preserved portion of the bone, present over only one-half of the posterior body depth from above.

The interoperculum is an elongated bone underlying the posteroventral part of the preoperculum and extending to the back of the lower jaw. It is thickened along its anterodorsal margin and thins posteroventrally. Fine tubercles are present below the anterodorsal margin.

The suboperculum is very elongate and deep, bearing irregular and rare, shallow grooves curving obliquely from near its anterodorsal margin. Its depth may be exaggerated by loss of the ventral portion of the operculum that would have partially overlain it.

Vertebral column. Only a single anterior vertebral centrum has been preserved. This is a simple bone, lacking any laterally developed fossae. A notochordal pit is present. Remains of several neural arches are present, including one which was probably associated with the pits in the basioccipital, behind the foramen magnum.

DISCUSSION

The genus *Euroka* has superficial morphological character states that suggest it could have affinities with one of the existing families of the Suborder Albuloidei, either the Pterothrissidae Gill, 1893 or the Albulidae Bleeker, 1859, both of which have living as well as fossil representatives. Of these, closest similarities lie with the albulids, a family known from the Upper Cretaceous from Europe and North America (Forey 1973). A third family, the Osmeroididae, was established by Forey (1973) and was considered to possess few of the specialisations of the albulids or pterothrissids but was none the less regarded as a link between the Elopidae at the base of the elopiform radiation and the more specialised albuloids. It could be argued that, because of the limited number of specimens involved in the establishment of *E. dunravenensis*, it would be prudent to refer *Euroka* to the Albuloidei *incertae sedis*, rather than to erect a further family, the Eurokidae. However, the specialised morphological character states in the new taxon, especially those associated with the roof of the mouth, support formal differentiation at this time.

The Australian material is derived from the marine Toolebuc Formation within the Eromanga Basin part of the Great Artesian Basin, reliably dated as Lower Cretaceous (latest mid to late Albian) on the basis of dinoflagellate and spore-pollen zonation (Moore et al. 1986; McMinn &

Burger 1986). Later but less convincing dating of the Toolebuc by Henderson (2004) based on ammonite work suggested slight refinement of the dating but still retained a Late Albian age for the Formation. This indicates that early elopomorph radiation in the Australian region included local lineages closely contemporaneous with the earliest of the recorded osmeroidids from the northern hemisphere. The material presented specialised morphology differing significantly from the later occurring albulid taxa.

Marine transgressions into the Great Artesian Basin were short-lived with limited access to open oceanic waters across the basement structure of the Euroka Arch, south of the present Gulf of Carpentaria. This suggests that access to new, niche opportunities in the epeiric sea could have resulted in relatively rapid evolutionary responses from taxa entering the Basin, leading to endemic forms with specialised features, departing from trends developed within the extracontinental gene pool. On the other hand,

TABLE 1. Differences between *Euroka* and *Albula*.

No	Character	*Euroka*	*Albula*
i	Anterior cranial roof	Relatively shorter	Elongated
ii	Dermethmoid	Posteriorly broad	Posteriorly narrow
iii	Anterior ethmoid area	Complex/blocky	Complex/ attenuated
iv	Vomer	With very large teeth	Needle-like teeth
v	Parasphenoid	Very broad esp. anteriorly	Less broad anteriorly
vi	Parasphenoid teeth	Edentulous	Many rounded teeth
vii	Cranial depth	Posteriorly very shallow	Relatively less shallow
viii	Posterior cranial width	Very wide	Relatively narrower
ix	Post-temporal fossa	Relatively small	Relatively larger
x	Subepiotic fossa	Insignificant	Large
xi	Subtemporal fossa	Almost lacking	Very large
xii	Otic bullae	Insignificant	Very inflated
xiii	Interorbital septum	Very thick	Thin
xiv	Hyopalatine series	Anterior block-like	Anterior long, thin
xv	Palatine teeth	Extremely large	Small teeth if present
xvi	Maxillary teeth	Few posteriorly, small	Edentulous
xvii	Supramaxilla	Two	Single
xviii	Premaxilla articulation	To single facet	Double articulation
xix	Infraorbitals	Reduced, robust	Thinner, expansive
xx	Mandible	Solid, deep, elongated	Short, tapering
xxi	Dentary base	Inflected	Not inflected
xxii	Dentary teeth	Large, anterior fangs	Fine needle-like band
xxiii	Retroarticular	Present	Absent
xxiv	Postarticular process	Prominent	Absent
xxv	Coronoid process	Low	High
xxvi	Quadrate articulation	Below orbit back	Below front of orbit
xxvii	Gular	Relatively large	Small if present
xxviii	Preoperculum	Sigmoidal, thickened	Boomerang-shaped
xxix	Interoperculum	Elongate, deep	Small
xxx	Suboperculum	Elongate, deep	Large, hooked
xxxi	Branchiostegal rays	20	15

the localities from which *E. dunraveneusis* have come are both close to the inflow/outflow over the Euroka Arch, in possibly shallower waters to the east and southeast. For this reason, establishment of the Family Eurokidae draws attention to the possibly unique evolutionary responses within this less interactive, possibly early albuloid lineage. Certainly, pre-existing familial and even ordinal diagnoses such as those presented by Forey (1973), with classifications modified as in Forey et al. (1996), would need to be altered considerably and probably unnecessarily to accommodate *Euroka*.

E. dunraveneusis differs significantly when compared with albulids, based on the living *Albula vulpes* (Linnaeus 1758). These differences are summarised in Table 1. The Lower-Middle Eocene remains of *A. oweni* (Owen 1840) from Europe and North Africa, illustrated and discussed by Forey (1973) show even fewer similarities with specific character states in *E. dunraveneusis* than are present in *A. vulpes*.

The enlargement of the orbitosphenoid in *E. dunraveneusis* by addition of a massively ossified septum is similar to but more solidly developed than that in the Albulidae and in *Flindersichthys* Longman, 1932 and other taxa (in press) also from the Albian marine sediments of Queensland. However, strengthening of the orbitosphenoid area by ossification of an interorbital septum to contact with the parasphenoid, has been stated to occur sporadically in other groups by Forey (1973), who considers this character to lack strong phylogenetic value. Strengthening of the linkages between the parasphenoid and the roof of the neurocranium would increase support for the roof of the mouth. This would assist in overcoming the stresses associated with the bites employing the solid structure and massive teeth of the anterior hyopalatine bones. It is interesting to note the lack of teeth on the parasphenoid at the back of the roof of the mouth in this regard. This is at variance with the general situation in albuloids where parasphenoid tooth development is usually considerable.

It is unfortunate that the preserved remains of *E. dunraveneusis* lack almost all of the post-cranial skeleton. Certainly, the fusiform shape of the neurocranium, including the strongly inflected base of the lower jaw and the apparent loss of supraorbital and most of the infraorbital elements suggests the possibility of an eel-like body form. The increased solidity of many of the neurocranial bones would argue against rapid swimming and could be associated with a less mobile, more sedentary existence, with the animals being secretive, awaiting passing prey rather than actively hunting for food. Large, gripping teeth would be advantageous in ensuring that any prey captured from concealment would be unlikely to escape as they were dragged back into the possible area of concealment. The eels of the elopioform Order Anguilliformes are represented in the fossil record from the Upper Cretaceous (Middle Cenomanian) but the morphology displayed by *E.dunraveneusis* is generally more in keeping with interpretation of the taxon as being more albuliform. The relatively poor knowledge of the fossil history of the eels, noted by Forey et al. (1996), at this time precludes consideration of *Euroka* as a possible stem group genus associated with anguilliform evolutionary radiation within early elopomorph radiation.

Regardless, the presence of *E. dunraveneusis* in the Albian fossil fish fauna of the Great Artesian Basin indicates that early elopomorph evolution was none the less more complex than was believed previously.

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